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ABSTRACT

The supply of and demand for skilled information technology (IT) workers were examined in a survey of sample of 1,000 medium/large IT companies and 1,000 medium/large non-IT companies that were selected randomly from a Dun & Bradstreet database. A total of 271 companies (149 IT and 122 non-IT companies) responded. Among the main findings/conclusions were the following: (1) approximately 190,000 positions for skilled IT employees are currently unfilled, which translates into 1 vacancy for approximately every 10 IT employees; (2) 82% of large and mid-size IT companies expect to increase their number of IT employees; (3) 71% of respondents believe the demand for IT workers is higher than for other skilled/trained workers; (4) 68% of IT companies cite a lack of skilled/trained workers as a barrier to their ability to grow; (5) increased recruiting and training efforts are, at best, a partial solution to the current difficulty of finding/retaining skilled IT workers; (6) education will be a key facet of any solution to the problem; and (7) both outsourcing of IT work to companies overseas and IT workers' salaries will likely increase. (Appended are information on the survey methodology and confidence level computation. Contains 20 tables and 12 references.) (MN)

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HELP WANTED:

THE IT WORKFORCE GAP AT THE DAWN OF A NEW CENTURY

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INFORMATION TECHNOLOGY ASSOCIATION OF AMERICA
ARLINGTON, VA

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HELP WANTED:

THE IT WORKFORCE GAP AT THE DAWN OF A NEW CENTURY

ITAA

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FOREWORD

Information technology (IT) companies are among the most innovative and fastest growing in America. This is an industry that barely existed two decades ago and yet today provides Americans with a higher standard of living and numerous outstanding employment opportunities.

However, a glaring problem has emerged that potentially threatens much of this good news: employers' inability to find enough employees skilled in information technology needed to grow, expand, and compete. Moreover, the problem is not limited to "high tech" firms. Companies like Federal Express that rely on information systems to service their customers find that a lack of skilled IT workers is hurting them as well.

Anecdotal information about this gap between companies' growth needs and the current supply of skilled IT workers has surfaced in the media from time to time. But this report by ITAA is the first to examine the issue and document the problem in a systematic fashion. We would like to thank Stuart Anderson of the Cato Institute, the principal researcher for this project, and Professor James Lynch of American University, who assessed the study's methodology.

ITAA believes the study demonstrates a significant challenge that needs to be addressed. We plan to work with federal, state and local governments, the education community and our own industry to formulate solutions to the serious issues raised herein. Finding these solutions is critical to moving America forward toward a prosperous future in the 21st century.

Harris N. Miller, President, ITAA

EXECUTIVE SUMMARY

The rapid advance of technology, the rise of the Internet, and the overall growth of the economy has created severe problems for companies seeking skilled information technology (IT) workers. A study by the Information Technology Association of America (ITAA) extensively surveyed large and mid-size IT and non-IT companies throughout the United States and found:

- The number of unfilled positions for IT employees at large and mid-size U.S. companies is approximately 190,000 nationwide. This can be considered a conservative estimate of the gap between companies' growth needs and the current availability of IT workers because the survey did not include small companies, non-profit organizations, or federal, state, and local governmental agencies and include their need for IT workers.

- At large and mid-size IT companies, one IT position is vacant for approximately every 10 IT employees working at these companies.

- Eighty-two percent of large and mid-size IT companies expect to increase the number of IT workers they employ. Only 2 percent expect to reduce their IT workforce. The findings are similar for non-IT companies.

- Seventy-one percent of companies believe the demand for IT workers is higher than for other skilled/trained workers.

- Sixty-eight percent of IT companies cite a lack of skilled/trained workers as a barrier to their companies' future ability to grow.

- Increased recruiting and training efforts are at best partial solutions to the current problems companies face in finding and retaining skilled IT workers. One-third of IT companies engage in full-time recruiting to fill IT positions at their companies, and U.S. companies overall spend billions on training their workers.

- Education will be a key facet of any solution to this problem. However, universities are not doing an adequate job currently in graduating students in sufficient numbers. From 1986 to 1994, the number of bachelor degrees in computer science awarded annually at U.S. universities fell by 43 percent (from 42,195 to 24,200). In addition, the skill level of those who graduate is a major source of concern for companies. Sixty-nine percent of IT companies say only "few" or "some" of applicants for their IT jobs possess the skills the companies are seeking.

The consequences of the current situation are:

1) In the absence of sufficient IT workers we can expect to see slower growth in the IT

industry and in non-IT companies that need such workers than we would have seen otherwise.

2) As companies scale back their plans for growth and make related adjustments, we can anticipate slower job growth and less wealth creation than we would have seen.
3) Slower than anticipated growth and less innovation ultimately will affect both the supply and quality of information technology goods and services Americans can enjoy and that other U.S. companies can use to increase the productive capacity in their own industries.
4) We will see an increased use of outsourcing IT work to companies overseas as a partial solution to the problem of unfilled IT positions here in the United States.
5) We can anticipate further increases in the salaries of IT workers. At a certain level, in a global market, U.S. companies risk their profitability if they must pay individuals premiums beyond that which customers are willing to pay for the product or service those employees produce. Increases in labor costs not matched by increases in productivity but caused instead by an inadequate supply of labor can make it difficult or impossible for a company to compete. The problems demonstrated are not confined to Silicon Valley firms, nor can we anticipate any quick resolution of this problem in the immediate future.

The purpose of this study is to explore the dimensions of a problem -- the lack of skilled IT workers in America -- and determine whether that problem is real. The evidence is clear that the problem is indeed both real and serious. It leads to at least one overarching conclusion: American schools and universities are not producing a sufficient number of students skilled in information technology to meet the needs of U.S. companies. This sets a challenge for those who believe technology and growth can increase prosperity. It is a challenge that will be with us as we move into the 21st century.

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INTRODUCTION

Conventional wisdom from newspaper headlines tells us that companies are "downsizing." Yet other headlines tell us that numerous companies cannot find a sufficient number of employees skilled in information technology (IT) to meet their growth needs. Which picture is correct?

Downsizing in America relates in great measure to what Joseph Schumpeter called the process of "creative destruction," whereby, through competition, jobs in some companies are destroyed, while new ones are created in competing companies, in different industries, and even elsewhere within the firms that lost jobs. This process helps ensure economic progress, though it rarely operates smoothly. "Creative destruction" and movement toward employing more IT workers has proven to be the case at AT&T, which was criticized for laying off more than 7,000 employees in 1996. As the *Wall Street Journal* reports, "While AT&T did eliminate about 7,700 jobs during the year, the reductions were mostly offset by increased hiring in the company's fast-growing wireless, Internet, customer-care and local-phone operations."[1]

Today, anecdotal evidence shows that jobs are being created at so brisk a pace in the information technology field that firms cannot find enough people to fill these positions. An inability to fill positions prevents companies from growing at their optimum level, thus slowing down innovation and growth in the U.S. economy and encourages U.S. companies to seek employees overseas through outsourcing or through relocating facilities.

The IT industry employs approximately 2 million people in the United States, according to the Bureau of Labor Statistics.[2] The Information Technology Association of America (ITAA), a non-profit trade association of over 11,000 IT companies, embarked on this study to determine whether the anecdotal reports of unfilled IT positions were correct, and if so, to determine to what extent the problem existed. In this report, information technology is defined as the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware.

The study involved surveys sent to a randomly selected sample of 2,000 large and mid-size IT and non-IT companies throughout the United States. Large and mid-size IT companies were defined in the survey as those that had SIC codes that identified those companies as IT and whose sales volume or employee size pushed them into the mid-size or large range of companies as defined by the U.S. Small Business Administration. SIC codes are the industry classifications used by the U.S. Department of Commerce. Large and mid-size non-IT companies were defined in the survey as those whose SIC codes fell outside of the IT industry and who employed 500 or more individuals. Initial responses arrived by mail and additional respondents answered after being contacted by telephone

over a two-week period. The result of this work is a systematic sample of large and mid-size IT and non-IT companies. (See Appendix for an in-depth discussion of the study's methodology.) This report is the most comprehensive analysis of this issue to date, and the results confirm much of the anecdotal information known to those in the IT field. It is hoped that other researchers will build upon this work and further document the serious issues raised here.

Chapter One examines the gap between the supply of, and demand for, skilled IT employees at U.S. companies. It presents the results of the ITAA survey and discusses material available elsewhere that supports the survey's findings. Chapter Two addresses the issue of recruitment and asks whether improved or more active recruiting could solve the problem of a lack of skilled IT workers at U.S. companies. Chapter Three examines training issues relevant to information technology and the U.S. workforce as a whole. Chapter Four looks at education as a possible solution to the lack of IT workers and examines the current state of U.S. education as it relates to IT. The conclusion summarizes the report's findings and offers a wider lens through which to view this issue. In the Appendix, ITAA asked James P. Lynch, Associate Professor, School of Public Affairs, American University, to assess the study's methodology and provide confidence intervals and ranges to the findings of the survey.

IT companies are among America's fastest growing and most entrepreneurial companies. Joseph Schumpeter wrote that "Entrepreneurial profit . . . is the expression of the value of what the entrepreneur contributes to production in exactly the same sense that wages are the value expression of what the worker 'produces.'"[3]

As we reach the close of the 20th century, the value of what America's IT workers and entrepreneurs produce continues to improve the standard of living of people across the United States and throughout the world. During much of this century we have heard about the planet's "scarce" resources. Yet in reality, the scarcest resource U.S. companies face today is not oil, coal, or copper, but skilled people. The ability of these companies to find the skilled people they need to grow and innovate will help determine how successfully the information revolution makes the transition into the 21st century.

CHAPTER ONE

Skilled IT Workers: The Gap Between Supply and Demand

Today, it can be said, employers everywhere need IT (information technology) workers and virtually nowhere can they be found in sufficient numbers. This need is encumbering both IT and non-IT companies, inhibiting their ability to grow and create more jobs and wealth in the American economy. And the problem appears to be global, as evidenced by reports from Canada, the United Kingdom, and elsewhere.

Anecdotally, the picture is clear, and the problem is not confined to just "high tech" companies. Article after article in major newspapers have reported on the problem that firms face in finding skilled IT workers. The problem is not confined to high tech firms but has spread to companies in other industries that need IT employees in order to facilitate their growth and efficiency. As *InformationWeek* reported in December 1996, "Federal Express Corp., lauded for its many technology innovations, still can't attract enough skilled IT workers. The competition for today's hottest skills is that tough."[4] Larry Panantera, chief information officer (CIO) at Kenosha, Wis. tool maker Snap-On, Inc., says, "Every company in nearly every industry has finally realized the value of technology and how it can improve productivity and profitability."[5]

To attract programmers and systems analysts, Federal Express established regional data centers in Colorado Springs, Orlando, Fla., and the Dallas suburbs. Federal Express' extensive training programs seek to infuse talented IS (information systems) staff with non-technical skills as well. "The incentive is to develop people and keep them," according to a FedEx executive.[6]

Yet Federal Express is not the only non-IT company experiencing serious difficulties in finding skilled IT employees. Paul Pershersky, VP and CIO of the Portland, Ore. utility Pacificorp, says, "There have been shortages of skills before. But this is among the worst in a long time."[7] At the national retail chain Wal-Mart, the company seeks to hire approximately 250 IT workers to its applications development team. Wal-Mart finds, however, that its Arkansas location makes it difficult to attract young people. After Kraft Foods closed a New York facility, the company could not get any of its 150 IT staffers to relocate to Chicago because every one of them already had other offers in the New York area.

Pages of employment ads provide some evidence of today's problems, and even front page stories in major newspapers have captured some of the dilemmas facing companies. "Good Jobs Go Unfilled Amid Some Shortages of Skilled Workers," blared a *Wall Street Journal* headline and "Area High-Tech Firms are Hiring, But Can't Find Enough Local Talent," reported the *Washington Post*.[8] But newspapers have actually come late to the story. Approximately a year earlier, a survey of high tech firms found over 22,000 job openings at just 16 companies polled. (See Table 1).[9]

Table 1
Examples of Job Openings - January 1996

Company/Consortium	Number of Unfilled Positions
Sematech* (nine companies)	10,000
Intel	3,000
Silicon Graphics	3,000
Microsoft	2,000
Applied Materials	2,000
3Com	1,100
Sun Microsystems	1,000
Adobe Systems	200
TOTAL	22,300

Source: Anderson, Empower America. Company data, interviews; An estimated 85%-90% of these job openings, for which qualified applicants have not been found, are for technicians or engineers. *Sematech is a nine-company consortium that includes, AMD, AT&T, Intel, IBM, Digital, Hewlett-Packard, Rockwell, Motorola, Texas Instruments, National Semiconductor. The 10,000 figure for Sematech does not include the 3,000 Intel jobs cited.

Forbes magazine surveyed 20 companies in an article entitled "Help Wanted: Urgent," and found that 15 of them provide bonuses to workers who refer new employees, and nine recruit overseas to fill positions in the United States. "If I had a good enough supply of engineers in the U.S. I would never have asked a manager of this company to fly to Bombay, India," says T.J. Rodgers, CEO of Cypress Semiconductor.[10] "I would rather just build a few more buildings in San Jose, California where everyone could be right next to each other and we wouldn't even need plane travel." Motorola and Texas Instruments have also established design centers in India and elsewhere.[11] Rodgers says, "At a certain point you just cannot find people at any price in San Jose."

GE Medical Systems, a Waukesha, Wis.-based unit of General Electric Co., gives $5,000 bonuses and airline tickets as awards to employees who recruit software personnel.[12] The evidence from numerous companies, across various industries, is compelling -- companies cannot find enough skilled IT workers.

ITAA Survey Results: Approximately 190,000 IT Vacancies Today at U.S. Companies

In response to the growing media stories and prompted by increasing concern by its own members, ITAA decided to systematically measure the gap between the needs of companies to hire skilled IT workers and the availability of such workers in the American economy. The results show a significant and pervasive problem.

In a systematic survey of large and mid-size IT and non-IT companies, ITAA found that a weighted estimate reveals there are approximately 190,000 unfilled IT jobs in America today. (See Table 2.) This number actually understates the overall demand for such workers, because ITAA did not survey small companies, non-profit organizations, or local, state, and federal government agencies and, therefore, did not include those employers' needs for skilled IT workers in this study.

The ITAA survey asked, "How many vacancies does your company have for employees skilled in information technology?" For large and mid-size IT companies in America this translated into approximately 95,000 vacancies overall, with the average number of vacancies per company at 33. Mid-size and large IT companies were defined in the survey as those that had SIC codes that identified those companies as IT and whose sales volume or employee size pushed them into the mid-size or large range of companies as defined by the U.S. Small Business Administration. (See Appendix for a full discussion of the survey's methodology.)

Among U.S. large and mid-size non-IT companies, the ITAA survey found today there are approximately 96,000 vacancies. For non-IT companies, the average number of vacancies per company for IT workers was between 4 and 5. Mid-size and large non-IT companies were defined in the survey as those whose SIC codes fell outside of the IT industry and who employed 500 or more individuals. There are far more non-IT companies than IT companies in the U.S. economy overall, so even an average of 4 to 5 vacancies at such companies translates into large numbers overall. At large and mid-size IT companies, one IT position is vacant for approximately every 10 IT employees working at these companies.

Table 2
Vacancies For IT Workers at U.S. Companies

TYPE OF COMPANY	NUMBER OF VACANCIES FOR SKILLED IT WORKERS
Large and Mid-Size IT Companies	95,000
Large and Mid-Size non-IT Companies	96,000
TOTAL	191,000

Source: ITAA Survey of U.S. companies. Weighted estimate.

The number of vacancies at U.S. companies is not the only indicator of the growing need for IT workers. The ITAA survey asked employers whether they expected to increase, reduce, or maintain the current level of IT employees in the coming year. The results found that among IT companies, 82 percent expected to increase the number of such employees and only 2 percent anticipated reducing their IT workforce. Fifteen percent said they would likely maintain the current number of IT workers at their companies.

For non-IT companies the results were similar. Fifty-six percent expected to increase their IT workforce in the coming year, while only 3 percent anticipated reducing it. Forty percent believed they would maintain the current number of IT workers at their companies.

Table 3
IT Companies Plans for Hiring IT Workers in the Coming Year

Increase the number of IT workers	82%
Maintain current level of IT Workforce	15%
Reduce the number of IT workers	2%

Source: ITAA Survey of IT companies.

Demand for IT Workers Higher Than For Other Skilled Workers

Companies clearly believe that the demand for workers skilled in information technology is

much higher than for other workers in the U.S. economy. In response to a question that asked companies to compare the demand for IT workers to other workers, 83 percent of IT companies said the demand for IT workers was higher. Only 3 percent believed it was lower, while 14 percent thought it was approximately the same. (See Table 4.) Seventy-one percent of IT and non-IT companies combined believed the demand for IT workers was higher than for other workers, according to the survey.

Table 4
IT Companies
The Demand for IT Workers Compared to Other Workers in the U.S. Economy

High demand for IT workers compared to other workers	83%
About the same demand	14%
Low demand for IT workers compared to other workers	3%

Source: ITAA Survey of IT companies.

Salary Increases Help Demonstrate Company Problems

IT workers are already among the best compensated employees in America. According to the Bureau of Labor Statistics, the typical manufacturing worker earns between $12 and $13 an hour[13], while as Tables 5 and 6 indicate, many IT positions pay $27 an hour up to $45 or even $70 an hour in total compensation.

The rising compensation of IT workers indicate the high demand for these individuals, as employers are bidding up their wages. According to a compensation survey completed by William M. Mercer, average hourly compensation for operating systems software architects and consultants rose nearly 20 percent from 1995 to 1996.[14] In the absence of dramatic increases in productivity by such individuals, these types of increases are clear indications of serious labor market competition and further evidence that a problem exists. (See Tables 5 and 6.) According to William M. Mercer, the average projected pay increase in 1997 in all sectors of the U.S. economy is 4.1 percent.[15]

Those who believe that such high wage increases are intrinsically good, even if caused by a lack of available workers, are not taking into account the overall loss to the economy when companies cannot grow because they cannot find needed workers. In addition, salaries can outstrip productivity gains for only so long before costs make it impossible for companies to remain price competitive on their products and services. This can cost consumers money, or simply mean sales lost to global competitors. In the long run, this difficulty of hiring the IT workers at the right price here in the United States will encourage many companies to relocate

major portions of their operations to other countries.

Table 5
IT Compensation in 1995 and 1996

Job Title	Percentage Increase in Hourly Compensation 1995-96	1995 Average Hourly Compensation	1996 Average Hourly Compensation
Operating Systems/Software Architect /Consultant	19.7%	$71.5	$85.6
Network Control Supervisor	17.6%	$47.7	$56.1
Operating Systems/Software Program./ Analyst Manager	17.2%	$78.7	$92.2
Customer Support Technical Associate	16.2%	$27.7	$32.2

Source: William M. Mercer.

Table 6
IT Compensation in 1995 and 1996

Job Title	Percentage Increase In Hourly Compensation 1995-96	1995 Average Hourly Compensation	1996 Average Hourly Compensation
Customer Service Supervisor	15.4%	$46.8	$54.0
Customer Support Techn., Intermed.	14.6%	$35.6	$40.8
Software Devel. Programmer/ Analyst, Lead/ Specialist	14.3%	$58.2	$66.5
Appl. Program./ Analysis Manager	12.9%	$71.7	$80.7
Software Develop. Architect	12.0%	$69.4	$77.7

Source: William M. Mercer.

Results Confirm Reported Trends

The ITAA research survey confirms much of the information publicly available on the demand for IT workers in the U.S. labor market. While media reports have presented primarily an anecdotal portrait, some surveys have provided results similar to those found by ITAA.

A Coopers & Lybrand survey of many of America's fastest-growing companies found that the most highly sought skills in today's job market are in information technology. Among fast-

growing service companies, the most desired but most difficult employees to find were qualified programmers, systems and networking professionals, and skilled computer personnel "who can improve the usage of software programs." Close to half of the executives said that their current inability to find enough skilled trained workers was a significant barrier to the company's prospects for growth.[16]

The ITAA survey asked the same question of IT company executives and found that 68 percent cited a lack of skilled/trained workers as a barrier to their company's future growth. (See Table 7) This barrier was cited nearly twice as often as other potential barriers.

Table 7
IT Companies
Will Any of the Following Represent Barriers to Growth Over the Next 12 Months for Your Company?

Lack of skilled/trained workers	70%
Economic conditions in the country	36%
Profitability or decreasing margins	36%
Taxation, legislation, or regulatory pressures	32%
Lack of capital investment	27%

Source: ITAA Survey of IT companies. Respondents were permitted to provide more than one answer.

When respondents to the ITAA survey were asked which would represent the *most* significant barrier to their company's growth, 50 percent said the lack of skilled/trained workers. Twenty-one percent cited economic conditions in the country. There was a tie for third at 11 percent each for lack of capital and profitability or decreasing margins. Last came taxation, legislation or regulatory pressures at 8 percent, with a few other answers volunteered as the most significant barrier to growth. (See Table 8.)

Table 8
IT Companies
Which Will Represent the Most Significant Barrier to Growth Over the Next 12 Months for Your Company?

1) Lack of skilled/trained workers	50%
2) Economic conditions in the country	21%
3) Profitability or decreasing margins	11%
3) Lack of capital investment	11%
4) Taxation, legislation, or regulatory pressures	8%
4) Other	8%

Source: ITAA Survey of IT companies.

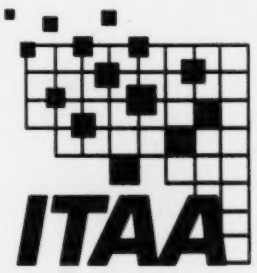
Another recent survey confirms ITAA's findings. A Deloitte & Touche Consulting Group survey shows that the problem is a global one. In a survey of CIOs worldwide, Deloitte & Touche found approximately 70 percent experienced difficulties recruiting client/server technical architects and distributed database experts. The CIOs found other types of IT specialists were similarly difficult to recruit.[17]

Conclusion

Clear evidence exists that the demand for skilled IT workers is far outstripping the current supply of such workers. The evidence is also clear that the demand for IT workers will continue to grow for the foreseeable future. The ITAA survey confirms information available elsewhere and estimates that approximately 190,000 unfilled positions for IT workers now exist in the U.S. economy at large and mid-size American companies. The data indicate that this will remain a problem in the coming years.

CHAPTER TWO

RECRUITMENT



Could companies compensate for the lack of skilled IT workers by stepping up their recruiting efforts? The evidence indicates that corporations are already exerting a great deal of time, effort, and money to recruit IT workers.

The ITAA survey found that more that one-third of IT companies engage in "full-time" recruiting efforts. The survey asked respondents, "Does your company fill IT positions primarily: a) by advertising specific positions when they become available, or b) by engaging in full-time recruiting efforts (job fairs, college recruiting, internet, etc.)?" The survey found that 35 percent engage in full-time recruiting efforts. (See Table 9.)

Table 9
How Do IT Companies Fill IT Positions?

Advertising specific positions when they become available	65%
Engage in full-time recruiting efforts	35%

Source: ITAA Survey of IT companies.

The ITAA survey also asked companies how much they spend on recruitment. The results confirm that many firms are spending large amounts of money to recruit IT workers. For some companies, 1996 was the first year they had to recruit through agencies. IT companies with more than 100 vacancies typically spent over $750,000 annually on IT recruitment, with some spending up to $1.2 million to $2 million a year. Table 11 provides some examples of annual recruiting expenses incurred by companies along with a significant number of vacancies for IT workers.

Table 10
IT Companies
Examples of Annual Costs to Recruit IT Workers at Five Sample Firms

Annual Recruitment Costs for IT Workers	Current Number of Vacancies for IT Workers
$2.5 million	100
$2 million	400
$1.2 million	100
$900,000	293
$750,000	100
$700,000	20

Source: ITAA Survey of IT companies.

Examples of heavy recruitment efforts in the IT industry have become legion. In a recent case reported by *Business Week*, Microsoft spent two years recruiting a developer from a rival company. The developer finally signed, on but only after Microsoft agreed to relocate his 27 dogs. "Have you ever heard of an airline that takes 27 dogs, in one shipment, when one is the size of a small pony?" asks Microsoft's recruiting director David A. Pritchard. *Business Week's* reporter added: "No. But then you never saw anything like today's software job market either."[18] Microsoft had set its sights on hiring approximately 2,000 people worldwide during 1997 and the second half of 1996.

The demand for workers is forcing changes in corporate human resources policies. Companies that rarely allowed telecommuting are now allowing people to work out of their home offices in order to attract and retain skilled IT workers. "Before, you had to be the Pope before we'd let you do that," says Carol A. Barz, CEO of Autodesk.[19]

At NEXT Software Inc., started by Apple Computer founder Steven Jobs and recently purchased by Apple, employees who refer an executive can earn up to $10,000 in bonus money, while an engineer can net $2,000[20] Internet startup firm Open Market, Inc. lured away Hewlett-Packard's Gary Eichorn with stock options for 5 percent of the company's stock and a $1 million signing bonus.[21]

Why the Demand for IT Workers?

A survey of Information Systems (IS) executives and recruiters conducted by *ComputerWorld* found answers for why the demand for IT workers has grown so rapidly. Technology was cited by respondents as the number one reason.

Indeed, there is little question that the Internet has helped boost demand for IT workers, leading to enormous growth in the industry. Existing companies have expanded, and new firms sprout up almost daily. "The Internet is the culprit. There were already labor shortages before. But now the rules of the game are being thrown out the window," says Jeffrey E. Christian, president of recruiters at Christian & Timbers.[22]

But the Internet is not the only reason cited. Executives and recruiters say that industry growth, the general economic conditions in the country, and industry restructuring are also responsible for the growth in demand for IT workers. (See Table 11.)

Table 11
Leading Factors Creating Demand for IT Workers

1) Technology Trends	48%
2) Industry Growth	36%
3) General Economic Conditions	35%
4) Industry Restructuring	22%
4) Other Factors	22%

Source: *ComputerWorld* survey of IS executives and recruiters.

Skills In Demand

Nationwide, the skills most in demand today are the ability to work with 1) networking operating systems, 2) operating systems, 3) RDBMS, 4) networking, and 5) languages/applications, according to a survey of IS executives and recruiters by *ComputerWorld.* Yet there exist clear regional differences in the demand for these skills. (See Table 13.)

In New England, development tools are the most sought-after IS skills. However, in the South Atlantic and Mountain regions, as well as parts of the central United States, an ability to work with operating systems is most in demand.

Table 12
Most-Sought IS Skills

	NATIONWIDE
1	Network operating systems
2	Operating systems
3	RDBMS
4	Networking
5	Languages/ Applications

Source: *ComputerWorld* survey of IS executives and recruiters.

The most in-demand job titles nationally in the industry, according to *ComputerWorld*, are 1) networking, 2) systems development, 3) top IS management, 4) PC support, and 5) tech services operations. (See Table 13.) The *ComputerWorld* survey found regional difference here as well. Networking is the most in-demand job title in the New England, South Atlantic, and Mountain regions, but systems development is the job title with the greatest demand in the West.

Table 13
Most In-Demand Job Titles

	NATIONWIDE
1	Networking
2	Systems development
3	Top IS management
4	PC support
5	Tech services operations

Source: *ComputerWorld* survey of IS executives and recruiters.

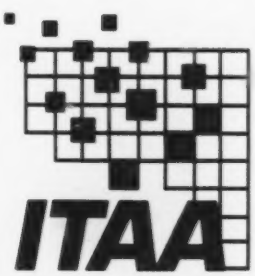
The ITAA survey, like *ComputerWorld's*, found regional differences in the demand for IT workers. Among IT companies with more than one facility, 33 percent identified significant regional differences related to IT worker demand, while 41 percent found no significant differences, and 23 percent said they did not know. According to the ITAA survey results, the problem of finding IT employees appears to have spread throughout the country.

Conclusion

Increased recruiting efforts or even the adoptions of new recruitment practices hold limited prospects for solving the problem of the lack of skilled IT workers in the American labor market. Approximately one-third of IT companies now engage in full-time recruiting in an attempt to fill the vacancies in their IT workforce. The evidence indicates that companies are already going to great lengths to recruit IT workers. Companies are finding that hiring away individuals employed by other firms does nothing to expand the pool of potential workers but merely shifts such individuals around in the marketplace.

CHAPTER THREE

TRAINING



Could companies compensate for the lack of skilled IT workers by increasing company training? The evidence is that even increasing training efforts will not solve today's labor problems in IT.

The ITAA survey found that virtually no IT companies fail to provide training to their IT employees. Only 3 percent of respondents were found to provide no training. On the other hand, approximately one-quarter spend between $100,000 and $1 million a year, while 66 percent spend $99,000 or less. Three percent spend more than $10 million a year training their IT workers, while 4 percent spend between $1 million and $10 million annually. The amount of money spent on training IT workers tends to correspond with the size of the company.

Table 14
How Much Do IT Companies Spend on Training IT Employees?

Annual Expenditures on Training IT Employees	Percentage of IT Companies
$99,000 or less	66%
$100,000 to $1 million	24%
$1 million to $10 million	4%
More than $10 million	3%
Do not provide training	3%

Source: ITAA Survey of IT companies.

Those IT companies with the most vacancies already are spending the most on training. The companies that spend more than $1 million a year, or more than $10 million annually on training have among the highest number of unfilled positions for IT employees. One IT company with 30 vacancies found it had to design a comprehensive training program for its new IT hires because it found the college curriculum "to be completely insufficient." Many ITAA members have designed their own training programs for the same reason.

In examining U.S. companies more generally, evidence shows that corporations are increasing the time and money they spend to train their workers. A July 1996 Bureau of Labor Statistics survey found that among U.S. companies with 500 or more employees, 75.5 percent had in the last 3 years increased the percentage of employees who receive formal training. Sixty-five percent of U.S. employers with 50 or more employees also increased that proportion, while only 3 percent decreased it.

The BLS survey found that, on average, companies in 1994 spent $139 per employee for the wages and salaries of in-house trainers; $98 per employee to pay outside trainers; $51 per employee to reimburse employees' tuition; and $12 per employee to pay for contributions to outside training funds.[23]

It is sometimes assumed that simply providing more training will turn almost anyone into an IT worker a company can employ profitably. Yet companies overwhelming reject that notion. The ITAA survey asked the question: "True or False? With additional training, most people in America who are unemployed could work for your company in IT." (See Table 15) An overwhelming 83 percent of IT companies said that notion was false, while only 17 percent thought it was true. The consensus of companies is that potential employees must possess a good background in IT before training can make them capable IT workers.

Table 15
IT Companies
"With additional training, most people in America who are unemployed could work for your company in IT."

False	**83%**
True	**17%**

Source: ITAA Survey of IT companies.

Cost is a major factor for companies to consider when deciding the proper level of training to invest in its employees. Training and salary combined can push IT workers beyond the price at which it is still profitable to employ them. As *InformationWeek* reports, "Training can present its own set of problems. For one, it's time-consuming and expensive."[24] Yet even companies that have had layoffs continue to spend large sums of money to train their employees. In 1996, AT&T and its spinoffs spent an estimated $1 billion educating and training its employees.[25]

Training employees in IT would seem to be a win-win for both worker and employer. And often that is the case. However, extensive training creates other issues. "You take a $45,000 asset, spend some time and money training him, and suddenly he's turned into an $80,000 asset," says Mary Kay Cosmetics CIO Trey Bradley. That can lead to another problem. New graduates trained in cutting edge technologies become highly marketable individuals and, therefore, are attractive to other employers. "We put $10,000 and a couple of years into training these kids, and the consulting firms come in and hire them," says Mary Ann Luczak, a VP at First Chicago.[26]

IT companies responding to the survey concurred that this was indeed a problem. "IT workers

come and go very fast -- they go onto greener pastures," said a personnel manager at one IT company. A human resources manager at another IT company said, "You lose IT employees through headhunters . . . After a year in business, they can get $10,000 more pay and leave you." Nevertheless, training and retraining will remain an integral part of the business landscape for U.S. companies and their IT employees.

Conclusion

Corporations desire a well-trained workforce and cumulatively spend billions of dollars annually to upgrade the skills of their employees. This is done to improve the abilities of their workforce and companies.

U.S. companies spend over $210 billion a year on the formal and informal training of their workforce, according to the National Association of Manufacturers. Informal training costs for U.S. employers reached $180 billion in 1991 and formal training was $30 billion during that year, according to the Industrial Relations Research Association.[27] As borne out by BLS statistics, the proportion of employees who receive formal training has risen in recent years. An estimated 85 percent of IS managers project to increase their spending on training over the next 3 years, according to an *InformationWeek* survey.[28]

For many companies, current training programs are already quite expensive. "We attract graduates with entry level salaries in the low 30s, and spend about $20,000 per person for 3 months worth of training," says Tom Olenzak, president of Cutting Edge. "Then we have to start giving them raises based on the training we've provided in order to keep them."[29]

The evidence is that relying primarily on further increases in company training efforts holds only limited prospects for solving the problem of the lack of skilled IT employees in the American labor market. Highly trained workers can easily leave an employer after receiving extensive training -- and frequently do. Still, competitive pressures already give the typical company every incentive to train its IT workers so they can perform to their full potential and help increase a company's bottom line. Training will remain an important ingredient for companies seeking to staff themselves with skilled IT workers. However, training will not solve the underlying problem of the increasing demand for workers that are unavailable in sufficient numbers in the U.S. marketplace.

CHAPTER FOUR

EDUCATION

Currently American universities are not graduating students in adequate numbers or with sufficient skills to fill the growing demands of U.S. companies. In fact, few people realize that the number of students who received math and computer sciences degrees at U.S. universities has actually *declined* over the past decade. From 1986 to 1994, the number of bachelor degrees in computer science awarded annually at U.S. universities fell by 43 percent (from 42,195 to 24,200). During a similar period, bachelor degrees in mathematics declined by approximately 9 percent and the number of associate degrees earned in math and computer sciences fell by 25 percent, from 13,679 to 10,255 (from 1986 to 1993).[30]

Table 16
Bachelor Degrees Earned in Computer Science at U.S. Universities: 1986-1994

1986	42,195
1994	24,200
Percentage change	-43%

Source: National Science Foundation, National Center for Education Statistics.

The Bureau of Labor Statistics rates computer scientists and systems analysts as occupations that will grow "faster than the average" through the year 2005. "The demand for 'networking' to facilitate the sharing of information will be a major factor in the rising demand for systems analysts. Falling prices of computer hardware and software should continue to induce more small businesses to computerize their operations, further stimulating demand for these workers," reports BLS. "In order to maintain a competitive edge and operate more cost effectively, firms will continue to demand computer professionals who are knowledgeable about the latest technologies and able to apply them to meet the needs of businesses. A greater emphasis on problem solving, analysis, and client/server environments will also contribute to the growing demand for systems analysts."[31]

The Bureau of Labor Statistics reports:

> Individuals with an advanced degree in computer science should enjoy very favorable employment prospects because employers are demanding a higher level of technical expertise. College graduates with a bachelor's degree in computer science, computer engineering, information science, or information systems should also experience good prospects for employment. College graduates with non-computer science majors who have had courses in computer programming, systems analysis, and other data processing areas, as well as training or experience in an applied field, should be able to find jobs as computer professionals.[32]

The number of students graduating from universities with the ability to work in information technology is crucial to closing the IT skills gap. Eighty-four percent of IT companies said that a B.A./B.S. is the highest level of education completed by most of the workers their companies hire in information technology, according to the ITAA survey. Nine percent said most of their IT workers had an M.A./M.S., and only five percent replied that high school was the highest level of education for most of their IT workers.

Table 17
IT Companies
Highest Level of Education Completed by Most of IT Workers Hired by Companies

B.A./B.S.	82%
M.A./M.S.	10%
High School	5%
Ph.D.	3%
Don't Know	1%

Source: ITAA Survey of IT companies.

The current state of American education has had an impact on the declining number of math and computer science majors at U.S. universities. A recent U.S. Department of Education study concluded:

- U.S. eighth grade mathematics classes are "not as advanced and not as focused as those in Japan and Germany."
- Topics in U.S. eighth grade math classes are by international standards taught at a seventh-grade level.
- U.S. math classes require "less high-level thought" than those in Germany and Japan.
- U.S. math teachers often try to teach students "how to do something, rather attempt to help them understand mathematical concepts, as in Japan."

Japan, in particular, the study found, has instructors who do a better job teaching tough material. "Based on videotapes of actual classroom instruction, the researchers found that U.S. math classes still largely focus on how to solve problems, while Japanese teachers do a much better job at helping students understand the concepts behind the solutions," according to the study.[33]

In releasing the study, U.S. Education Secretary Richard Riley said, "Every student should enter middle school and junior high school with a firm grasp of arithmetic, but clearly

employers want problem solvers, people who have mastered the basics and can apply that knowledge to new situations."[34] Overall, in mathematics U.S. eighth graders "score below the national average."

A 1992 study conducted by the Educational Testing Service (ETS) ranked U.S. 13-year-olds last in science and next to last in mathematics. What was the only category in which U.S. 13-year-olds led the world? Hours spent each week watching television. While Japanese eighth graders were found in the 1996 Education Department study to watch about the same amount of TV as their American counterparts, Japanese students endure a brutal exam preparation regime to gain entrance to junior high, high school, and college that is unheard of in America.[35]

The problem is not solely one of American universities. Many students are choosing not to enter computer-related fields. The U.S. Education Department study said that the math skills of U.S. eighth graders were similar to their counterparts in England and Germany, but did not comment on academic achievement in high school. Data indicate that U.S. students' interest in math and science wanes with time. In one study of four million high school students surveyed, 750,000 expressed an interest in science and engineering as sophomores. Yet by their senior year the number fell to 600,000 and by the time college began the number was 300,000. Only 200,000 would go on to complete a B.S. degree in engineering or the natural sciences, and only 10,000 attained a Ph.D.[36]

Fewer than half of American high school graduates complete Algebra II or chemistry, which are prerequisites for college-level mathematics or science.[37] According to the National Research Council, about three-quarters of U.S. high school graduates would fail a college freshman math or engineering course.[38] And at Purdue University, a 1987 study of the freshman class found that of 95 chemistry majors, 40 percent required remedial mathematics.[39]

Two rays of light shine through in the international studies of math and science. First, the most encouraging note in the U.S. Education Department's report is that "If an internal talent search to select the top 10 percent of all students in 41 [tested] countries in mathematics, 5 percent of U.S. students would be included. In science, 13 percent would be included."[40] Second, through immigration, many of the top students from other countries come to the United States to study and stay to work for American companies as well as U.S. government

and university research facilities. These two facts indicate that America still retains its ability to produce or to attract to its shores some of the best minds in the world.

Education, Training, and Immigration

A few prominent individuals have attempted to argue that American businesses are unconcerned with U.S. education and in training their employees because they can hire skilled immigrants and nonimmigrants.[41] Former Labor Secretary Robert Reich has stated, "Too many employers are using the [H-1B] program to avoid their responsibility to train U.S.

workers for these important high tech jobs."[42] Former Senator Alan Simpson (R-WY), who last year tried to further restrict employment-based immigration, also argued that employers may have limited interest in education and training programs because of the availability of foreign-born workers.[43]

The ITAA survey specifically restated the Reich/Simpson argument on immigrants and found that companies categorically rejected the premise. The survey asked the question: "True or False? Because your company can hire skilled immigrants, you have little incentive to train your workers or improve the U.S. education system." Ninety-six percent of companies overall viewed it as False." In fact, only 4 percent of IT and non-IT companies combined thought the statement to be true.

Table 18
IT Companies
"Because your company can hire skilled immigrants, you have little incentive to train your workers or improve the U.S. education system."

False	96%
True	4%

Source: ITAA Survey of companies. Results of IT and non-IT companies are combined.

It makes more sense to see skilled immigrants as part of the solution to the lack of American workers skilled in IT, rather than to blame them for somehow causing the problem. After all, companies are poorly positioned to improve unilaterally the state of public education in America. And as pointed out in Chapter Three, companies devote considerable sums to training their employees. Moreover, most U.S. companies do not hire skilled foreign nationals on H-1Bs and even among those who do they normally represent a fraction of their total labor force.[44]

Employers Say Many Graduates Lack Key Skills

Approximately 33 percent of job applicants overall tested in 1995 by U.S. companies could not pass a basic skills test in reading and math.[45] Among those graduates who are entering the marketplace in search for IT careers, companies also find that many do not have the skills employers need. Sixty-nine percent of IT companies answered "few" or "some" when asked in the ITAA survey to assess what proportion of applicants for IT jobs have the skills the companies are seeking. Only 23 percent answering the ITAA survey said that "most" have the skills for which they are looking, while 4 percent said "all" do. One percent replied that "none" have such skills.

Table 19
IT Companies
"Among applicants applying for positions that require knowledge of IT, what proportion have the skills you are seeking?"

Some	52%
Most	23%
Few	17%
All	4%
Don't Know	2%
None	1%

Source: ITAA Survey of IT companies.

Approximately two-thirds of IT companies surveyed believe that American colleges and universities are not producing enough students with sufficient knowledge and skills in IT for companies like theirs. (See Table 20.)

Table 20
IT Companies
"True or False? American colleges and universities are producing enough students with sufficient knowledge and skills in information technology for companies like yours."

False	62%
True	38%

Source: ITAA Survey of IT companies.

In Northern Virginia, companies say they have approximately 10,000 unfilled positions of trained workers at high-tech companies. Yet only 560 of the students who graduated with bachelor's degrees from public universities in Virginia majored in computer science. A little over 1,500 graduated with concentrations in engineering.[46]

Donations to Universities

Do IT companies donate money to U.S. colleges and universities? Many do. Clearly such donations are discretionary and can only be made if a company is financially secure. Also, larger companies possess greater financial ability to make such contributions than do small and mid-size firms. Twenty-eight percent of IT companies in the ITAA survey said their firms donate money to a U.S. college or university, while 49 percent said they did not, and 22 percent did not know. Among those who said their companies make such donations, 40 percent replied that their companies contribute money to help improve a university's curriculum in the IT field. That means that approximately 11 percent of IT companies overall are now donating money to improve the IT curriculum on university campuses, according to the survey.

The Council for Aid to Education reports that in 1993, U.S. corporations donated more than $2.5 billion to education in America, with an estimated $1.8 billion going to higher education.[47] For example, one of the IT companies with 100 vacancies donates $5 million a year to universities and between $1 million and $2 million earmarked to help develop IT curriculum, according to the ITAA survey.

The International Experience

The United States is not the only country confronting the educational challenges that surround IT. India is increasing the number of its students educated in IT and is looking to continue to increase the IT workforce pool and keep more of them at home. These IT students, increasingly the product of Indian universities, work for companies in Bangalore or elsewhere

that often perform IT outsourcing from America and Europe.

A recent report by Canada's Software Human Resources Council concluded that "Unfilled vacancies, as reported by employers, have jumped dramatically within three years and will probably continue to climb unless aggressive methods are sought for increasing the supply of new entrants to the software workforce." The report warned, "If new entrants are not created, either out of the school system or by retraining other workers, the unfilled vacancies will increasingly mean lost opportunity for wealth creation in Canada."[48]

The Canadian study, similar in respects to the ITAA survey of American firms, surveyed Canadian software companies and found that almost half had job vacancies that remain unfilled. The study notes that "Skilled workers can only come from three sources: new graduates from our school system, the retraining and skills upgrading of existing workers, or recruiting skilled immigrants."[49]

The Canadian report makes no specific recommendations but implies that a combination of education, retraining, and immigration will be needed to combat the skills dilemma facing Canadian employers in the software industry.

In the United Kingdom, a debate has taken place on giving portable computers to all 9 million school children in the UK as a way to improve IT education and schooling more generally. Paddy Ashdown, MP, Liberal Democrats, arguing for the plan, has written that "[A]t present, our education system is failing to teach our schoolchildren even the basics of IT. . . . According to Her Majesty's inspectors, too many pupils are receiving only a 'very limited diet of IT and to a relatively superficial level.'" This sentiment is shared by Labor's Tony Blair, who could become the UK's next prime minister.

In the UK, IT skills courses are now compulsory in all General National Vocational Qualifications. The country also has national targets for 75 percent of young people to achieve a specific level of IT competency of certain core skills. Ian Taylor, the minister for science and technology, believes that "Everything conspires to make the UK one of the best environments in Europe -- for IT consumers, producers, and for investors." He favors "free and open competition" as the way for the UK to develop its IT productive capacity, and warns against trying to centrally plan technology development by pointing to a 1956 report that advised the government that "four computers would satisfy the needs of the whole nation."[50]

Ireland has seen a growing demand for software professionals, with the number of jobs advertised increasing by 59 percent from 1994 to 1995, according to a study of six Irish newspapers. During this period 24 percent of all jobs advertised were in the electronics, computers and software industries. A concern about too few workers for growing IT companies has led the government to encourage universities to increase their IT course offerings.[51]

Even in places as diverse as Iceland and Vietnam, the need to improve the education system to produce more IT workers has become clear. In Iceland, the Ministry of Culture and

Education supports pilot projects at universities to help strengthen the teaching of information technology. In Vietnam, the government and universities are desperately trying to attract IT professors to the country to help develop Vietnam's human capital.[52]

Recommendations from IT Companies

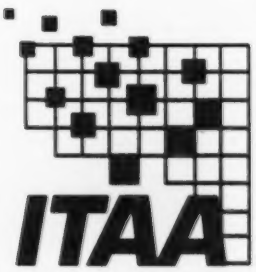
Investing college students with more real world experience in IT was the most common suggestion among IT companies on how to improve the college curriculum. Frequently, those companies that offered suggestions recommend increased emphasis on internships and "real business-world knowledge."

Related to that suggestion was company advice for instructors. One IT executive said universities should "hire instructors with background in the needed areas of IT and who can teach." Another executive suggested that "Universities need to put instructors through the regimen of the work world."

Some companies complained that universities simply are not doing a very good job of preparing graduates. "They train people in areas different than the job market," said a human resources manager at one IT company. Another IT company put it more bluntly: "Universities need to do a great deal of work in producing usable IT workers who can function without heavy on-the-job training." There is still a need for Cobol, insisted some survey respondents, while another encouraged universities to put less emphasis on mainframe knowledge. But one IT company president offered the simplest recommendation: "Increase the supply of graduates."

CHAPTER FIVE

CONCLUSION



This study has documented the following information:

First, the number of unfilled positions for IT employees at large and mid-size companies is approximately 190,000 nationwide. Because ITAA did not survey small companies, non-profit organizations, or federal, state, and local governmental agencies and include their need for IT workers in the study, this a conservative estimate of the gap between companies' growth needs and the current availability of IT workers in America.

Second, 82 percent of large and mid-size IT companies expect to increase the number IT workers they employ. Only 2 percent expect to reduce their IT workforce.

Third, 68 percent of IT companies cite a lack of skilled/trained workers as a barrier to their company's future ability to grow.

Fourth, increased recruiting and training efforts are at best partial solutions to the current problems companies face in finding and retaining skilled IT workers. One-third of IT companies engage in full-time recruiting to fill IT positions at their companies.

Fifth, education will be a key facet of any solution to this problem. However, universities are not currently doing an adequate job of producing students properly skilled in IT and in graduating such students in sufficient numbers. Sixty-nine percent of IT companies say only "few" or "some" of applicants for their IT jobs have the skills the companies are seeking.

The Consequences of Inaction

The current inability of U.S. companies to hire the skilled IT employees they need carries costs to the United States and to its economy. IT is a knowledge-based industry that relies on people as its most valuable resource. The more skilled people in the industry, the more innovations, and the better for society as a whole.

This current inability of companies to hire the people they need slows future job growth in the industry and leads to less wealth creation in the U.S. economy overall. Information technology has become a leading export for the United States, an area of comparative advantage for America. "More than 40 percent of our manufactured exports fall into the high-tech category," according to the U.S. Department of Commerce. [53] The Commerce Department also cites economic research that indicates science and technology "may account for as much as fifty percent of American economic growth."[54]

Eventually, companies compensate for a difficulty in hiring the workers they need. In the restaurant industry, for example, owners compensate for a lack of help by building smaller facilities or by not expanding existing ones. But such solutions hurt consumers, limit the growth of an industry, and affect the overall growth of the economy. Those in construction who build restaurants and the suppliers of goods and services to restaurants are hurt by the limits placed on that industry's ability to grow. Similarly, in the information technology field,

the solution for many companies will be to scale back plans for growth. That will make them less competitive internationally. Outsourcing IT work to overseas firms will increasingly be the only option for many companies.

The consequences of the current situation are clear. First, in the absence of sufficient IT workers we can expect to see slower growth in the IT industry and in non-IT companies that need such workers than we otherwise would have.

Second, we can anticipate slower job growth and less wealth creation than we would have seen as companies scale back their plans for growth and make related adjustments. Seventy percent of IT companies now cite a lack of skilled/trained workers as a barrier to their company's future growth. Stephen Fuller, a professor of public policy at George Mason University, says of Virginia companies' inability to fill their needs for IT workers, "The economy will grow slower than it could have grown if this problem is not fixed."[55]

Third, slower than anticipated growth and less innovation ultimately will affect both the supply and quality of IT goods and services Americans can enjoy and that other U.S. companies can use to increase the productive capacity in their own industries.

Fourth, we will see an increased use of outsourcing IT work to companies overseas as a key alternative to filling unfilled IT positions here in the United States. Today, an estimated 75 of the Fortune 500 now contract in India for software development.[56] Half of the IT companies surveyed by ITAA expected that the lack of skilled IT workers would not ultimately prevent them from getting the workers they need, which may project an increasing reliance on overseas outsourcing, an anticipation of scaling back growth plans, or a combination of the two.

Fifth, we can anticipate further increases in the salaries of IT workers. Salaries for IT workers have already been rising rapidly, and increasingly we see firms raiding other companies IT employees, indicating that we cannot anticipate that salary and benefits increases alone will solve the problem of the high and growing demand for IT workers in the U.S. economy. At a certain level, in a global market, U.S. companies risk their profitability if they must pay individuals premiums beyond that which customers are willing to pay for the product or service those employees produce. At some price, increases in labor costs can make it difficult or impossible for a company to compete. Companies that do not remain profitable do not stay in business for very long. The lack of mobility of labor across international borders, whether through practical or legal restrictions, means that a current inability to hire skilled people in America pushes U.S. companies to outsource abroad or relocate facilities internationally to obtain labor at a competitive price.

APX, a contract engineering firm, has 600 openings for skilled positions of all types, included those in IT. "There aren't enough people in the world to do all the work we have right now, "says Ralph Miller, president of APX. His company even recruited 42 engineers from California and invested in them with substantial training. Yet the experiment proved to be a failure, with only 8 of the employees staying on. "APX's recent efforts to fill high-skill jobs

show just how daunting the problem can be," reports the *Wall Street Journal*. "APX has raised its pay level a bit but not a great deal because, it says, it is limited by how much its clients, the auto companies, are willing to pay."[57]

Despite being hemmed in by clients' willingness to pay, salaries for many positions in the IT industry have seen double-digit percentage increases in the past year, with the annual rate of increase for many key positions over the past five years hovering between 4.7 percent and 15.4 percent, according to William M. Mercer.[58] For example, from 1995 to 1996, the salaries of operating systems/network programmers increased by 17.2 percent.

The purpose of this study is to explore the dimensions of a problem -- the lack of skilled IT workers in America -- and determine whether that problem is real. The evidence is clear that the problem is both real and serious, leading to at least one overarching conclusion: American schools and universities are not producing a sufficient number of students skilled in information technology to meet the needs of U.S. companies. This sets a challenge for those who believe technology and growth can increase prosperity. It is a challenge that will be with us as we move into the 21st century.

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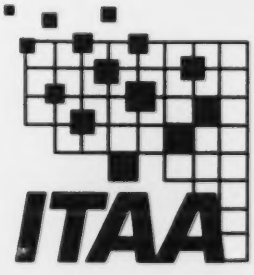
APPENDIX I

Survey Methodology



The ITAA survey was sent to 1,000 IT companies and 1,000 non-IT companies defined as large and mid-size. The sample was shaped by dividing IT and non-IT companies into two universes. The U.S. Department of Commerce SIC codes for the IT companies were carefully selected and the companies were only drawn from those above the size standard established for "small businesses" by the Small Business Administration. For the non-IT companies the dividing line to eliminate small businesses was the Commerce Department's definition of 500 to 999 for mid-size businesses and 1,000 or more for large businesses. The SBA criteria makes finer distinction for different IT SIC codes. For example, for some SIC codes they use an annual revenues cutoff. This allows for more precision with regard to the IT companies than using a simple 500 or more employee criteria.

The SIC codes used in the study for IT companies were 3571 (Electronic Computers), 3572 (Computer storage devices), 3575 (Computer terminals), 3577 (Computer peripheral equipment, not elsewhere classified), 3674 (Semiconductors and related devices), 4812 (Radio/telephone communications), 4813 (Telephone communications, except radio), 4822 (Telegraph & other communications), 3661 (Telephone and telegraph apparatus), 3663 (Radio & TV equipment), 7372 (Prepackaged software), 7373 (Computer integrated systems design), 7376 (Computer facilities management), 5045 (Computer peripherals and software), 7374 (Computer on-line services, internet services), 7379 (Computer related services, not elsewhere classified), 8742 (Computer systems analysis Services), and 8243 (Data processing schools).

Non-IT companies were defined by using the remaining SIC codes, with the exception of 7371 and those designated for non-profit organization and the governmental sector.

The companies were selected randomly utilizing a Dun & Bradstreet database. Initial responses arrived by mail and additional respondents answered after being contacted by telephone over a two-week period. ITAA found that among the IT companies, those who responded to the survey by mail actually had fewer vacancies per company than those who answered the survey after being telephoned. This argues that whatever non-randomness there is in the responses to the survey, the selection bias may be upwards. In other words, the survey may underestimate the number of vacancies. A total of 271 companies answered the survey either through the mail or telephone; 149 IT companies and 122 non-IT companies. Those answering the surveys were primarily presidents, CEOs, CFOs, COOs, CIOs or senior human resource executives, with the balance being human resources specialists within the companies.

Other surveys, such as those cited in this study by Coopers & Lybrand and Deloitte & Touche, provide further evidence that the results of the ITAA survey are in line with previous research in this area. Finally, under the assumption that the response bias was randomly distributed, we employed the usual statistical techniques appropriate for random samples. To compute confidence intervals for our point estimates specific computations are included in

APPENDIX II

Confidence Interval Computation

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The Survey of Information Technology Companies and the Survey Non-Information Technology Companies discussed in the foregoing report were administered to *samples* of information technology (IT) companies and non-information technology companies (NIT). Because the statistics from these surveys are based upon samples and not populations, some attention must be paid to the effects of sampling error. To that end, we present in this appendix confidence intervals for all of the statistics used in the report that were computed from the IT and Non-IT samples. These confidence intervals indicate the interval around the sample statistic in which the population parameter will fall in nine samples out of ten.

The computations made here assume that the samples are either simple random samples or stratified random samples. While the samples were drawn randomly, the level of non-response is quite high and this could result in a biased sample. To the extent that this occurs the confidence intervals presented here will be in error. It is impossible to determine at this time the extent of bias in the samples resulting from non-response.

The computation of confidence intervals is complicated by the fact that there are three different samples employed in the report--the sample of IT companies, the sample of NIT companies and the combined sample of IT and NIT companies. In addition, there are two different types of sample statistics for which confidence intervals must be calculated--proportions and sums or counts. The fact that some of the statistics presented in the report are weighted estimates further complicates the computation of confidence intervals. The methods used to compute confidence intervals are described below by sample and type of statistic.

Confidence Intervals for Proportions Based Upon the IT Sample.

The IT sample is a simple random sample drawn from a frame of large and middle-sized IT companies. Of the 1,000 surveys mailed to this sample, 149 were returned for an effective sample size of 149. Confidence intervals for these proportions were computed as follows:

$$P_s \pm 1.645 \sqrt{(P_s Q_s)/N}$$

where :

P_s=sample proportion

$Q_s = 1 - P_s$

1.645= Z statistic that corresponds to the most extreme 5% of the distribution

N_s = sample size

The sample proportion, the table in which it is located, and the upper and lower limit of the confidence interval are presented in Table 1.

Table 1: Computation of Confidence Intervals for Proportions IT Sample Only

Table Number	Proportion	Confidence Interval	
		Lower Limit	Upper Limit
Table 3/1	0.82	0.768	0.871
Table 3/2	0.15	0.102	0.197
Table 3/3	0.02	0.001	0.038
Table 4/1	0.83	0.779	0.88
Table 4/2	0.14	0.093	0.186
Table 4/3	0.03	0.007	0.052
Table 7/1	0.7	0.638	0.761
Table 7/2	0.36	0.295	0.424
Table 7/3	0.36	0.295	0.424
Table 7/4	0.32	0.257	0.382
Table 7/5	0.27	0.211	0.329
Table 8/1	0.5	0.433	0.566
Table 8/2	0.21	0.155	0.264
Table 8/3	0.11	0.068	0.151
Table 8/4	0.11	0.068	0.151
Table 8/5	0.08	0.043	0.116
Table 8/6	0.08	0.043	0.116
Table 9/1	0.65	0.586	0.713
Table 9/2	0.35	0.286	0.413
Table 14/1	0.66	0.596	0.723
Table 14/2	0.24	0.182	0.297
Table 14/3	0.04	0.013	0.066
Table 14/4	0.03	0.007	0.052
Table 14/5	0.03	0.007	0.052
Table 15/1	0.83	0.779	0.880
Table 15/2	0.17	0.119	0.220
Table 17/1	0.82	0.768	0.871
Table 17/2	0.1	0.059	0.140
Table 17/3	0.05	0.020	0.079
Table 17/4	0.03	0.007	0.052
Table 17/5	0.01	-0.003	0.023
Table 19/1	0.52	0.453	0.586

Table 19/2	0.23	0.173	0.286
Table 19/3	0.17	0.119	0.220
Table 19/4	0.04	0.013	0.066
Table 19/5	0.02	0.001	0.038
Table 19/6	0.01	-0.003	0.023
Table 20/1	0.62	0.5551	0.684
Table 20/2	0.38	0.3151	0.444

Confidence Intervals for Proportions Based on the Combined IT and Non-IT Samples

The IT and Non-IT samples were combined in Table 19 to estimate the proportion of companies of either type that did not invest in training because of the availability of foreign labor. In this case, the combined sample was treated as a stratified random sample with three separate strata The IT sample was considered one strata. The sample of Non-IT companies with between 500 and 999 employees was treated as a second strata and the sample of Non-IT companies over 1000 employees was treated as a third strata. The confidence intervals were computed as follows:

$$P_s \pm 1.645 \ (S_s/\ddot{O}N_s)$$

where :

$$P_s = {}^3S_{i=1} W_i P_i$$

and

$$S_s = {}^3S_{i=1} W_i^2 S_i^2$$

where

$$S_i = \ddot{O} P_i Q_i/N_i$$

P_i= proportion in strata

N_i= number of sample cases from strata i

W_i= number of units in the population constituting strata i / number of units in the population

The proportion of respondents saying that the question in Table 19 is false was . 96. The upper limit of the confidence interval was .993 and the lower limit was .926 with a confidence level of 90 percent.

Confidence Intervals For Sums or Counts from the IT, Non-IT and Combined

Samples

The estimates of vacancies presented in Table 2 are the sum of vacancies reported by respondents in the survey weighted up to the population. One estimate is presented from the IT sample, one from the Non-IT sample and one from the combined sample. Consequently confidence intervals must be estimated for each of these samples.

Confidence Intervals for Estimates of the Number of Vacancies in the Population of IT Companies

The confidence interval for the sum of vacancies from the IT sample can be estimated as follows:

$$T \pm 1.645 \ (S_t/\ddot{O}N_s)$$

where

$$T = X_s \ M$$

X_s= mean

M= population

and

$$S_t = \ddot{O}S_t^2$$

where

$$S_t^2 = S_x^2 \ M^2$$

$$S_x^2 = {}^nS_{i=1} \ (X_i - X)^2/N_s$$

and

$$SE_t = SE_x \ M$$

where

$$SE_x = S_x/\ddot{O}N_s$$

The lower limit of the resulting confidence interval is 48,000 and the upper limit is 141,000 with the point estimate of 94,708.

Confidence Interval for the Number of Vacancies in the Stratified Sample of Non-IT Companies

The procedures followed here were similar to those followed for the IT sample except

that the computation of the mean and standard error for the Non-IT sample took account of the fact that this sample contained two strata--a strata for firms with 500 to 999 employees and a strata for firms of 1000 or more employees. This required estimating the mean and variance for both strata and then combining these estimates into an estimate for the combined sample. This was done in the following manner:

$$X_s = {}^{2}S_{i=1} W_i X_i$$

and

$$S_s = {}^{2}S_{i=1} W_i^2 S_i^2$$

$$S^2_i = {}^{n2}S_{i=1 j=1} (X_{ij} - X_i)^2 / N_i$$

N_i= number of sample cases from strata i

W_i= number of units in the population constituting strata i / number of units in the population

Once these sample statistics were computed, they were simply multiplied by the number of firms in the population to estimate the population parameters--the number of vacancies and the standard error for the number of vacancies. This was done in the following manner

$$T = X_s \ M$$

where

X_s= mean

M= population

and

$$S_t^2 = S_x^2 M^2$$

and

$$SE_t = M \ SE_x$$

where

$$SE_x = S_x / \ddot{O}N$$

$$S_x = \ddot{O} S_x^2$$

The confidence interval for T was computed by

$$T \pm 1.645\ (SE_t)$$

The lower limit of the resulting confidence interval is 70,000 and the upper limit is 119,000 around a point estimate of 96, 642. The increased precision of this smaller, stratified sample (n=117) compared to the large simple random sample of IT firms (n=149) is due to the large differences in the number of vacancies across the strata (The average number of vacancies in large firms was 5.5 as compared to 2.5 in the small firms.). This is not surprising because the strata were formed on size of firm which will be highly related to *number* of vacancies.

Confidence Interval Computation for the Combined IT and Non-IT Samples

In estimating confidence intervals for the combined IT and Non-IT samples we employed the same general procedures used to compute confidence intervals for the stratified Non-IT sample. The IT sample was treated as a third stratum with the Non-IT firms under 1000 employees considered the first stratum and the Non-IT firms with more than 1000 employees treated as the second stratum. As in the previous section, the mean and variances were computed for each stratum, these statistics were weighted and then summed to estimate the statistics for the combined sample, and the statistics for the combined sample were adjusted to reflect the population.

The combined sample estimates were computed as follows:

$$X_s = {}^3S_{i=1} W_i X_i$$

and

$$S_s = {}^3S_{i=1} W_i^2 S_i^2$$

$$S_i = {}^nS_{i=1\ j=1} (X_{ij}-X_i)^2/N_i$$

N_i= number of sample cases from strata i

W_i= number of units in the population constituting strata i / number of units in the population

Once these sample statistics were computed, they were simply multiplied by the number of firms in the population to estimate the population parameters--the number of vacancies and the standard error for the number of vacancies. This was done in the following manner

$$T = X_s\ M$$

where

X_s= mean

M= population

and

$$S_t^2 = S_x^2 M^2$$

and

$$SE_t = M\ SE_x$$

where

$$SE_x = S_x/\ddot{O}N$$

$$S_x = \ddot{O}S_x^2$$

The confidence interval for T was computed by

$$T \pm 1.645\ (SE_t)$$

The lower limit for the resulting confidence interval was 152,000 and the upper limit was 230,000 for the point estimate of 191,000 vacancies.

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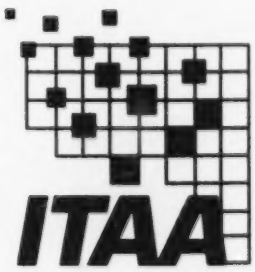

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